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August 3, 2016

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Written *ex parte* presentation in IB Docket No. 11-109; IBFS File Nos. SES-MOD-20151231-00981, SAT-MOD-20151231-00090, and SAT-MOD-20151231-00091

Dear Ms. Dortch:

Attached are two recent letters that were sent to the Co-Chairs of the National Executive Committee for Space-based Positioning, Navigation and Timing (“EXCOM”) responding to a letter from the Chair of the National Space-based PNT Advisory Board (“PNTAB”) concerning Ligado’s proposal to modify its licenses and expressing concerns about the compatibility of Ligado’s operations with GPS devices. The first letter is from Doug Smith, President and CEO of Ligado Networks LLC, and in it Mr. Smith writes to “correct the record on a number of errors [in the PNTAB letter] that present a very inaccurate picture of Ligado’s current proposal.” The second letter is from Dennis Roberson, President of Roberson and Associates, LLC, and Mr. Roberson states that “PNTAB fundamentally misunderstands and mischaracterizes Ligado’s proposal. In addition, PNTAB’s letter contains several inaccurate and misleading statements relating to the proper engineering criteria for assessing potential interference to GPS applications.”

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Ms. Marlene H. Dortch

August 3, 2016

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Please direct any questions to the undersigned.

Sincerely,

/s/

Gerard J. Waldron

Counsel to Ligado Networks LLC

cc: Ron Repasi
Charles Mathias
Jennifer Tatel
Paul Murray
Bob Nelson

July 13, 2016

Honorable Robert O. Work
Deputy Secretary of Defense
Honorable Victor M. Mendez
Deputy Secretary of Transportation
National Executive Committee for Space-based Positioning, Navigation and Timing
Herbert C. Hoover Building, Room 2518
1401 Constitution Ave., NW
Washington, D.C. 20230

Re: Response to June 13, 2016 Letter from PNT Advisory Board

Dear EXCOM Co-Chairs:

I am writing to respond to a June 13, 2016, letter to you from John Stenbit, Chair of the National Space-Based PNT Advisory Board, concerning alleged interference with PNT services that the letter states could be caused if Ligado's license modification applications are granted by the Federal Communications Commission (hereinafter "Stenbit Letter"). I submit this letter to correct the record on a number of errors that present a very inaccurate picture of Ligado's current proposal. Specifically:

1. *"Unfortunately, the latest Ligado proposal being considered by the FCC is not materially different from the previous LightSquared proposal which the PNT Executive Committee (EXCOM) unanimously rejected with its January 2012 letter to the National Telecommunications and Information Administration (NTIA), based on the widespread radio frequency interference (RFI) observed in extensive laboratory and live-sky testing conducted in 2011."* Stenbit Letter at 1.

That statement is not accurate because the current Ligado proposal is dramatically different from the earlier proposal. Figure 1 illustrates the old LightSquared proposal in terms of power levels and bands utilized.

Figure 1. Old LightSquared Proposed Bands and Power Limits.

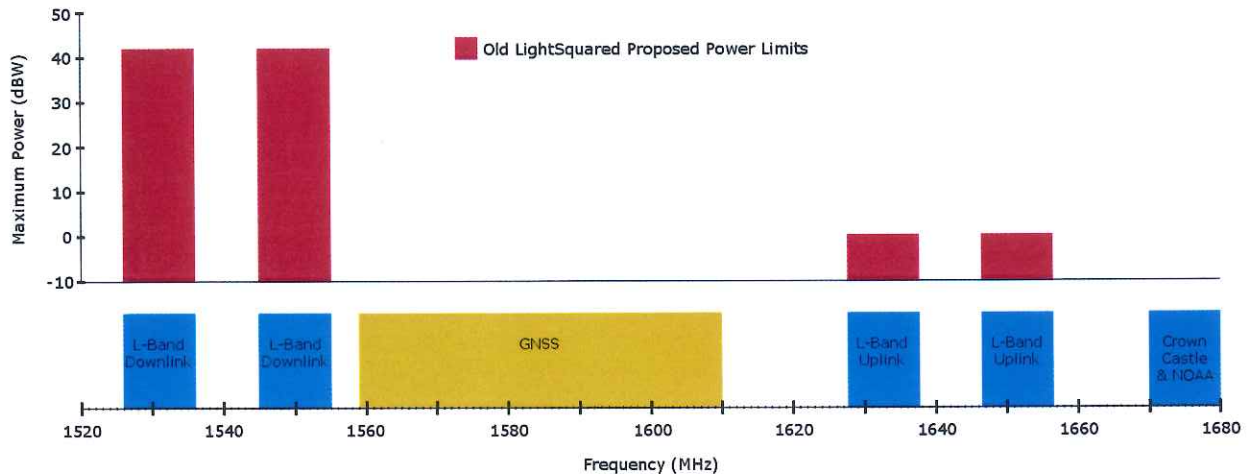


Figure 2 depicts the current Ligado proposal that is pending before the FCC.

Figure 2. New Ligado Proposed Bands and Power Limits.



As demonstrated above, under the new Ligado plan, which has been submitted to the FCC for approval and has recently been subjected to a vigorous public comment cycle, there are four substantial differences.

- Ligado has agreed to relinquish terrestrial use of the band closest to the GPS band.
- Ligado has agreed to lower its power levels.
- Ligado has agreed to substantially reduce out-of-band emissions (OOBE) in all bands.
- Ligado's new proposal creates a 17.5 MHz "guard band" of separation between the edge of the GNSS band and the edge of Ligado's uplink band closest to the GPS

and a 23 MHz guard band between the edge of the GNSS band and the edge of Ligado's downlink.¹

Further evidence of the profound difference between the current Ligado proposal and earlier proposals is that the major GPS device companies, including Deere & Co., Garmin International, Inc., Trimble Navigation Limited, NovAtel Inc., and Leica Geosystems Inc., have filed with the FCC stating on the record that they either support or do not object to grant of the Applications.

2. *"The operation of high-power terrestrial mobile wireless transmitters in a frequency band immediately below where GPS operates is arguably the worst possible use of two adjacent radio frequency bands – space-based navigation and terrestrial wireless broadband communications – for the following reasons. First, GPS is not a communications system. It is a radionavigation system that relies upon nanosecond-level (a billionth of a second) synchronization of transmitter and receiver clocks via one-way signals. The 50 bit-per-second data message included in the GPS signal is of secondary importance to the formation of precise measurements of the distance traveled by a radio signal moving at the speed of light. In contrast, terrestrial networks designed for high-speed communications, such as streaming video to mobile phones, transfer data at rates on the order of 10 million bits per second – a fundamentally different use of the radio spectrum than one-way satellite ranging. Second, GPS is a space-based system, subject to the immutable laws of physics that dictate that signals arriving from satellites in orbit over 20,000 km above are weaker than even the miniscule natural radiation generated by the Earth itself."* Stenbit Letter at 1.

This paragraph contains a number of errors. The statement in the first sentence is simply irrelevant since its premise is false: as demonstrated above, the Ligado plan abandons terrestrial use of the frequencies immediately below GPS. It is also incorrect in its categorical assertion that Ligado's transmitters will be high-power. Ligado has substantially reduced its power levels. The rest of the paragraph suggests that because GPS and LTE are different systems, and GPS signals are weak, that LTE cannot operate immediately below GPS. This assertion fails on many levels. For one, LTE signals are not immediately below GPS — there is a 23 MHz separation between the GNSS band edge and a 26.42 MHz separation between LTE and the GPS band edge at 1563.42 MHz. Second, the notion that GPS signals are weak in an absolute sense is irrelevant. Received signals in any spectrum dependent system are "weak" relative to transmitted levels. The relevant coexistence question that all spectrum regulators must examine is whether the receiving system is impacted by the potential interferer at a certain specific level at which the potential interfering signal is expected to be experienced at the receiver. This is exactly what Roberson and Associates tested and found that there is no impact. NASCTN is currently conducting similar tests.

¹ In practice, the guard band is even greater. The GPS band within the GNSS band is 1563.42 to 1587.42 (1575.42 MHz +/- 12 MHz). Thus, there is a 26.42 MHz separation between downlink and GPS band edge at 1563.42, and 22.58 MHz separation between uplink and GPS band edge at 1587.42.

3. *“In spite of these unique characteristics, many parties are calling for ‘sharing’ of spectrum used by, or adjacent to GPS and other space systems with terrestrial services. True ‘sharing’ of radio spectrum is only possible among compatible systems. Sharing without compatibility is repurposing by another name, and a recipe for harmful interference.”* Stenbit Letter at 1.

It is inaccurate and contrary to the basic structure of a spectrum allocation system to assert that spectrum is being “shared” between Ligado and GPS. Ligado proposes to operate in separate, licensed frequency bands that are removed from the GNSS and GPS bands and at dramatically reduced OOB and power levels. That licensed spectrum allocated to a prescribed use is in no way, shape, or form “shared” with nearby users. Instead, the licensee of the subject spectrum is obligated to utilize its spectrum in a manner that ensures it is a good spectrum neighbor. That is exactly what Ligado’s license modification with the reduced OOB and power levels sets forth. And to be clear, Ligado’s operations are not directly adjacent to GPS; because of the 23 MHz guard band below the GNSS band edge and the 17.6 MHz guard band above the GNSS band edge, Ligado in fact operates on distant adjacent channels

* * *

A number of statements in the Stenbit Letter on 1 dB and various engineering issues merit a response which our engineering team will submit shortly. But I want to strongly reject the suggestion that Ligado’s operations would in any way put in jeopardy the substantial benefits that GPS devices bring to the American economy. For a thorough analysis of the potential additive economic benefits of a Ligado deployment consistent with our new proposed operating parameters, please consider the submission in the FCC record by Coleman Bazelon of the Brattle Group, which concluded that FCC grant of the applications would generate \$250 to \$500 billion in social welfare without presenting any risk to GPS devices or the GPS industry.² To further establish that Ligado’s operations would have no impact on GPS devices, the company arranged for private testing by Roberson and Associates to ensure that was not the case, and those 300-pages of evidence and 11,477 pages of data have been submitted to the FCC for all parties to review. We went one step further and sought out additional testing by a qualified government entity (NASCTN) to assess our proposed new plan of operation and its potential impact on GPS devices. Moreover, our substantially reduced OOB and power levels have satisfied virtually all of the major GPS device manufacturers that our operations can comfortably coexist with their devices and not impact their consumers.

² Coleman Bazelon, “Putting Mid-Band Spectrum to Work: Sharing Between Ligado Networks and Its GPS Neighbors,” May 23, 2016, at 9, *attached to* Comments of Ligado Networks LLC, IB Docket No. 11-109 (May 23, 2016).

As dedicated policymakers seeking to promote GPS as well as promote innovation and the American economy, I ask you to look at the facts and data in the record as they exist today, not as they may have existed before. We stand ready to provide EXCOM with any additional information to make sure its deliberations are informed by the best and most accurate information available.

Sincerely,



Doug Smith
President & CEO

cc: John Stenbit, Chair--PNT Advisory Board



Roberson and Associates, LLC
Technology and Management Consultants

August 2, 2016

Deputy Secretary of Defense Robert O. Work
Deputy Secretary of Transportation Victor M. Mendez
National Executive Committee for Space-Based Positioning, Navigation and Timing
Herbert C. Hoover Building, Room 2518
1401 Constitution Ave., NW
Washington, D.C. 20230

Response to June 13, 2016 Letter from John Stenbit, Chair, National Space-Based PNT Advisory Board

Dear EXCOM Co-Chairs:

I write in response to a letter addressed to you from John Stenbit, Chair of the National Space-Based PNT Advisory Board (PNTAB), dated June 13, 2016, concerning Ligado's license modification applications. As Doug Smith, President and CEO of Ligado Networks, explained in his letter to you of July 13, 2016, PNTAB fundamentally misunderstands and mischaracterizes Ligado's proposal. In addition, PNTAB's letter contains several inaccurate and misleading statements relating to the proper engineering criteria for assessing potential interference to GPS applications. I write to correct the record with respect to those issues as they relate to Ligado's proposal.

As an initial matter, from a technical perspective, Ligado's proposal departs substantially from the old LightSquared plan. Most significantly, Ligado's proposal relinquishes terrestrial use of the band nearest the GNSS band, thus creating a guard band of at least 23 MHz below the GNSS band (and 27 MHz below the GPS operating band). This is the equivalent of nearly four television channels worth of separation between the GNSS (GPS) band and Ligado's proposed use of the band. Ligado also proposes significantly reduced power levels in its uplink bands, and proposes operational deference to FAA limitations on power levels in the lower downlink band to prevent any potential interference with navigational aids. Across *all* bands, Ligado's proposal substantially reduces out-of-band emissions (OOBE) when compared with the defunct LightSquared plan.

Many of PNTAB's statements are simply irrelevant or erroneous due to PNTAB's apparent inattentiveness to the basic aspects of Ligado's proposal. Its statement that "operation of high-power terrestrial mobile wireless transmitters in *a frequency band immediately below where GPS operates* is arguably the worst possible use of two adjacent radio frequency bands" has no bearing on Ligado's proposal, given that Ligado completely abandons terrestrial use of *a frequency band immediately below where GPS operates*.¹ PNTAB's statement that received GPS signals are "weaker than even the miniscule natural radiation generated by the Earth itself"

¹ Letter from John Stenbit, Chair of PNTAB, to EXCOM Co-Chairs, June 13, 2016, at 1 (emphasis added).

bears no relevance to the question of whether *Ligado's proposal* can coexist with GPS applications.

The specific question of Ligado's proposed coexistence with GPS applications is exactly what I and several of my colleagues at Roberson and Associates have researched and tested, and what is currently being tested by the National Advanced Spectrum and Communications Test Network (NASCTN). Yet PNTAB's letter fails to even consider these directly applicable studies — despite the fact that our test procedures, data, and results have been publicly disclosed and have been readily available online for months.² PNTAB writes that “over half of the US\$55B annual benefit of GPS comes from the *Precision* class of GPS receivers,” and that “[t]herefore, the interference to precision receivers must be assessed as part of any compatibility study.” I agree, and that is why Roberson and Associates tested and reported on precision receivers, in addition to cell phone, non-certified aviation, and general navigation devices — collectively representing the vast majority of GPS receiver types. After extensive testing, including the “live-sky testing” PNTAB requests, Roberson and Associates concluded that all of these types of receivers, including precision receivers, are currently compatible with Ligado's proposal, or can readily be made compatible, using appropriate antennas that have adopted the good design practice (widespread since 2011) of integrating filtering to enhance the robustness of the precision receivers to rejecting out-of-band signals. PNTAB also states that “impacts to *Timing* receivers must be assessed.” NASCTN is conducting just such tests, which is appropriate given NIST's expertise with respect to timing receivers and precision timing in general, and which will complement Roberson and Associates' testing.

To the extent that the attachment to PNTAB's letter listing various specific GPS applications is intended to suggest that *all* use cases must be tested for *all* possible users (“current and future”), I urge you to consider that such “census” testing is not appropriate and would be virtually impossible to complete in a finite amount of time. In my professional judgment, responsible and appropriate testing must encompass dominant and representative use cases and potential user groups, supplemented by particularly critical use cases and uses. Roberson and Associates' test plan did exactly that. It reflects feedback we requested and received in many venues from many stakeholders, including from the National Public Safety Telecommunications Council (NPSTC), and various industry and government groups.

PNTAB states that it “insists” on a 1 dB Carrier-to-noise density power ratio (C/N_0) standard as “the only acceptable method for protecting space-based PNT services,” purportedly because “decades of regulatory precedence [*sic*]” supports a 1 dB standard. In fact, the FCC

² Roberson and Associates, LLC, Results of GPS and Adjacent Band Co-Existence Study (May 9, 2016), <https://ecfsapi.fcc.gov/file/60001841466.pdf>; Roberson and Associates, LLC, GPS and Adjacent Band Co-Existence Study: Summary of Method and Results (May 9, 2016), <https://ecfsapi.fcc.gov/file/60001841466.pdf>; Roberson and Associates, LLC, GPS Sensitivity Measurement Plan v2 (May 9, 2016), <https://ecfsapi.fcc.gov/file/60001841466.pdf>; Roberson and Associates, LLC, Test Data, <https://ecfsapi.fcc.gov/file/60001841467.pdf>, <https://ecfsapi.fcc.gov/file/60002098747.pdf>, <https://ecfsapi.fcc.gov/file/60002098748.pdf>, <https://ecfsapi.fcc.gov/file/60002112538.pdf> (collectively “*Roberson Co-Existence Study*”).

criteria for harmful interference examines *actual* harm as opposed to an artificial surrogate.³ A 1 dB degradation in C/N_0 does not correlate with an impact to key performance indicators or any harm to the user. This fact is empirically evident in the Roberson and Associates test results and data, and has been corroborated by theoretical analysis.⁴ Interestingly, at times, based on GPS satellite positioning, the test results showed a greater than 1 dB decline in C/N_0 in the absence of any LTE signal at all, and not surprisingly, with no impact to the position accuracy of the GPS device under test. Actual testing of GPS devices demonstrates that, across GPS devices under various conditions, even a substantial change in C/N_0 can coincide with a decrease, increase, or no change in the device's position error.⁵ While 1 dB may be a criterion that has been applied for *in-band* interference for other applications, the criterion is not applicable to the question of the Ligado proposal's compatibility with GPS, as it has never been applied to a situation involving *adjacent* (or in this case *distant*) band interference.

PNTAB further states that it “strongly endorses the Department of Transportation (DOT) Adjacent Band Compatibility (ABC) assessment as the most scientifically valid approach to date.” But DOT's testing relies on the 1 dB criterion, which has been scientifically demonstrated — both theoretically and experimentally — to be unreliable for assessing the impact of adjacent (or distant) band signals on GPS functionality. Moreover, it is not at all clear that the DOT testing has been done in a way that is repeatable and verifiable by independent third-parties, a standard requirement for scientifically valid testing. Further, unlike the Roberson and Associates test, the DOT test was a closed test with no opportunity for all stakeholders to observe the test as it was being conducted.

Finally, the Roberson and Associates test results and the various agreements between the leading GPS device providers and Ligado demonstrate that nearly all of the “key criteria” proposed by PNTAB support the conclusion that Ligado's proposal does *not* harmfully interfere with GPS and GNSS applications. The FCC process, informed by Roberson and Associates and NASCTN testing, ensures that Ligado's proposal would not “affect[] existing and evolving uses of space-based PNT services.” GPS device manufacturers' agreements with Ligado, verified by Roberson and Associates' test results, indicate that all classes of GPS receivers in all operating modes will not be harmed even by the maximum proposed transmitted LTE power.

As you consider this issue, I urge you to review the directly relevant testing by Roberson and Associates, which accurately assesses the specifics of Ligado's proposal for potential interference to GPS applications. I or my team can provide any additional information that would assist you in your deliberations. To facilitate this I have three specific requests: First, I would respectfully request to meet with either or both of you to discuss these matters further, so

³ 47 C.F.R. § 2.1(c) (“*Harmful Interference*. Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations.”).

⁴ *Roberson Co-Existence Study*, *supra* note 2; see also Mark A. Sturza, Changes in C/N_0 Are Not a Reliable Indicator of KPI Impact (June 6, 2016), <https://ecfsapi.fcc.gov/file/60002097963.pdf>.

⁵ See *id.*

that the interagency process can move swiftly to a positive, scientifically grounded conclusion; Second, my team and I would very much like to review the DOT sponsored test results. Finally, I would note that after years and years of debate and study, the PNT should provide their proposal for an approach that preserves the focus on the critical GPS service while enabling terrestrial use of this extremely critical spectrum in the vicinity of the GPS band.

Sincerely,

/s/

Dennis Roberson

cc: John Stenbit, Chair, PNTAB